RESULTS OF IGNITABILITY TEST FOR JANAF AD HOC IGNITABILITY PANEL USING THE LOCKED-STROKE COMPRESSOR (U)

9 May 1960

U. S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND

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MAY 60 9P FERGUSON, JOHN D.;
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DESCRIPTORS: *IGNITION, *SOLID ROCKET PROPELLANTS, COMPRESSORS, TEST EQUIPMENT, TEST METHODS, TESTS (U)

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NAVORD Report 6849

RESULTS OF IGNITABILITY TEST FOR JANAF AD HOC IGNITABILITY PANEL USING THE LOCKED-STROKE COMPRESSOR (U)

By

JOHN D. FERGUSON

Approved by: EVAN C. NOONAN, Chief
Physical Chemistry Division

ABSTRACT: In accordance with the request of the Ad Hoc Committee on Ignitability the ignition energy of each of five propellants (TRX-135-D, QQd-112, ANP-2639-AF, N-5 and PPC-127A) has been determined using the locked-stroke compressor (1,2,3). The relative ignitability of each propellant has been calculated with respect to TRX-135-D. Results using other test methods are also reported for comparison.

PHYSICAL CHEMISTRY DIVISION
CHEMISTRY RESEARCH DEPARTMENT
U. S. NAVAL ORDNANCE LABORATORY
White Oak, Silver Spring, Maryland

NAVORD Report 6849 9 May 1960

This report provides ignition data on propellants selected for comparison by various test methods. The locked-stroke compressor used to obtain the data was designed as a research tool. It is not recommended as a test instrument. Absolute values of ignition energy may be considerably in error due to the assumptions necessary in the heat transfer calculations. Comparative values between propellants are believed much more reliable. This research was conducted under Task NO 506-925/56015/01040, "Guided Missile Rocket Motor Ignition Systems, Supporting Research".

W. D. COLEMAN
Captain, USN
Commander

Albert Lightbody
ALBERT LIGHTBODY
By direction

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TABLES

RESULTS OF IGNITABILITY TEST FOR JANAF AD HOC IGNITABILITY PANEL USING THE LOCKED-STROKE COMPRESSOR (U)

I. INTRODUCTION

In conjunction with the SPIA Ad Hoc Committee on Ignitability (5,6,7), a round robin ignitability test program is being conducted. The main purpose of this program is to select a standard test for determining the ignitability of solid propellants. In order to compare existing ignitability test systems the ignitability of each of four propellants is being determined by each system.

The primary purpose of this report is to publish the results obtained using the locked stroke compressor (2,3) and to compare these results with those using other test methods.

II. APPARATUS AND INSTRUMENTATION

The locked-stroke compressor and instrumentation are discussed in NavOrd Reports 2840 and 3818 (2,3). Only a brief description will be given here.

The unit is designed to compress a gas so rapidly that its temperature and pressure rise almost adiabatically. The final 80% of the pressure rise occurs in 2 to 5 milliseconds and the compression piston is locked into position at the peak of its stroke. A schematic of the compressor is given in Figure 1.

III. EXPERIMENTAL PROCEDURE AND RESULTS

A. Experimental Procedure

1. Preparation of Sample

The samples which were tested in the compressor were cut from a one inch (2.5 cm) thick piece of propellant as shown in Figure 2a. This one inch thick piece of propellant was obtained two inches (5.1 cm) below one end of the bulk sample, Figure 2b. The tested samples were .19 inches (.48 cm) in diameter and 1.0 inch (2.5 cm) long. The samples were inhibited by putting modelling clay on .25 inches (0.64 cm) of each end so as to leave .50 inches (1.3 cm) of sample exposed in the center, Figure 2c.

2. Testing of Sample

A complete description of the testing procedure is given in NavOrds 2621 and 2840 (1,2).

3. Propellant Formulations

Propellant compositions are given in Table I.

B. Discussion of Results

The results obtained using the locked-stroke compressor are presented in Table II. The propellants under study are listed in order of increasing difficulty to ignite:

TRX-135-D
QQd-112
ANP-2639-AF
N-5
PPC-127A

The relative ignitability of each propellant is calculated in comparison with TRX-135-D by dividing its ignitability by that of TRX-135-D and multiplying by 100. These relative ignitabilities are listed in Table III for each test method (7). The data from all test methods, except the Olin Mathieson Laboratory and the Naval Ordnance Laboratory, show that ignitability becomes more difficult in the following order:

TRX-135-D
N-5
ANP-2639-AF
PPC-127A

Results on QQd-112 were reported only by the Naval Ordnance Laboratory, therefore it is excluded from this comparison. Although these methods agree as to the relative order of propellant ignitability there is little agreement as to how much easier TRX-135-D is to ignite than any of the other tested propellants.

IV. SUMMARY

The locked-stroke compressor shows ease of ignition to decrease in the order:

TRX-135-D
QQd-112
ANP-2639-AF
N-5
PPC-127A

A comparison of the results of other test methods shows ease of ignition to decrease in the order:

TRX-135-D
N-5
ANP-2639-AF
PPC-127A

The results obtained by the Olin Mathieson Laboratory agree with the results obtained by the Naval Ordnance Laboratory.

The results of these tests definitely indicate that the energy source as well as the apparatus must be defined in order to characterize ignitability.

TABLE I

PROPELLANT FORMULATIONS*

QQd-112	Wt. %
Ammonium perchlorate	57.20
Petrin acrylate	15.10
Triethylene glycol dinitrate	17.50
Polyester 920	0.25
EHM (Proprietary item)	1.60
Aluminum	8.15
Ethyl centralite	0.20
N-5	
Nitrocellulose (12.6% N)	50.0
Nitroglycerin	34.9
Diethylphthalate	10.5
2-Nitrodiphenylamine	2.0
Lead salicylate	1.2
Lead 2-ethyl hexoate	1.2
Candelilla wax	0.2
TRX-135-D	
NH_4ClO_4	74.00
LP-33	18.81
Butyl carbitol formal	2.09
Quinone dioxime	1.39
Diphenyl guanidine	0.70
MgO	1.00
Fe_2O_3	2.00
Sulfur	0.01
ANP-2639-AF (Approximate)	
Polyurethane binder	20.0
NH_4ClO_4	60.0
Aluminum	15.0
Additives	5.0
PPC-127A	
PBVP (90% butadiene, 10% 2-methyl-5 vinylpyridine copolymer)	11.01
NH_4ClO_4	81.05
Carbon black	2.48
Butyl carbitol formal	2.20
Flexamine	0.33
MgO	0.49
Malori blue	1.94
Hi-Sil 233	0.50

*Ref. 4 and 8

TABLE II

IGNITABILITY AS DETERMINED BY LOCKED STROKE COMPRESSOR

Propellant	Ignition Energy $\left(\frac{cal}{cm^2}\right)$
TRX-135-D	.205
QQd-112	.234
ANP-2639	.299
N-5	.351
PPC-127A	$>$.451

TABLE III

RELATIVE IGNITABILITIES OF PROPELLANTS*

Apparatus	Closed Bomb					Vented Bomb	Arc Image		Tube Furnace	Compressor		Explod. Bridge Wire
	Black Powder			Metal Oxid. Igniter								
Activity	OML	Picatinny	NPP	Rohm and Haas	OML	Aerojet	SRI (300 psi)	SRI (0 psi)	SRI	NOL	NOTS	Librascope
Propellant												
TRX-135-D	100	100	100	100	100	100	100	100	100	100	100	100
ANP-2639	168	194	247	140	138	255	200	940	230	146	145	310
N-5	216	178	183	111	103	182	67	620	60	171	127	720
PPC-127A	-	1590	600	313	917	>760	1600	-	-	>220	>235	-

* Reference 7

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5. Minutes of the First Meeting of the JANAF Ignitability Panel, 5 June 1957. Confidential

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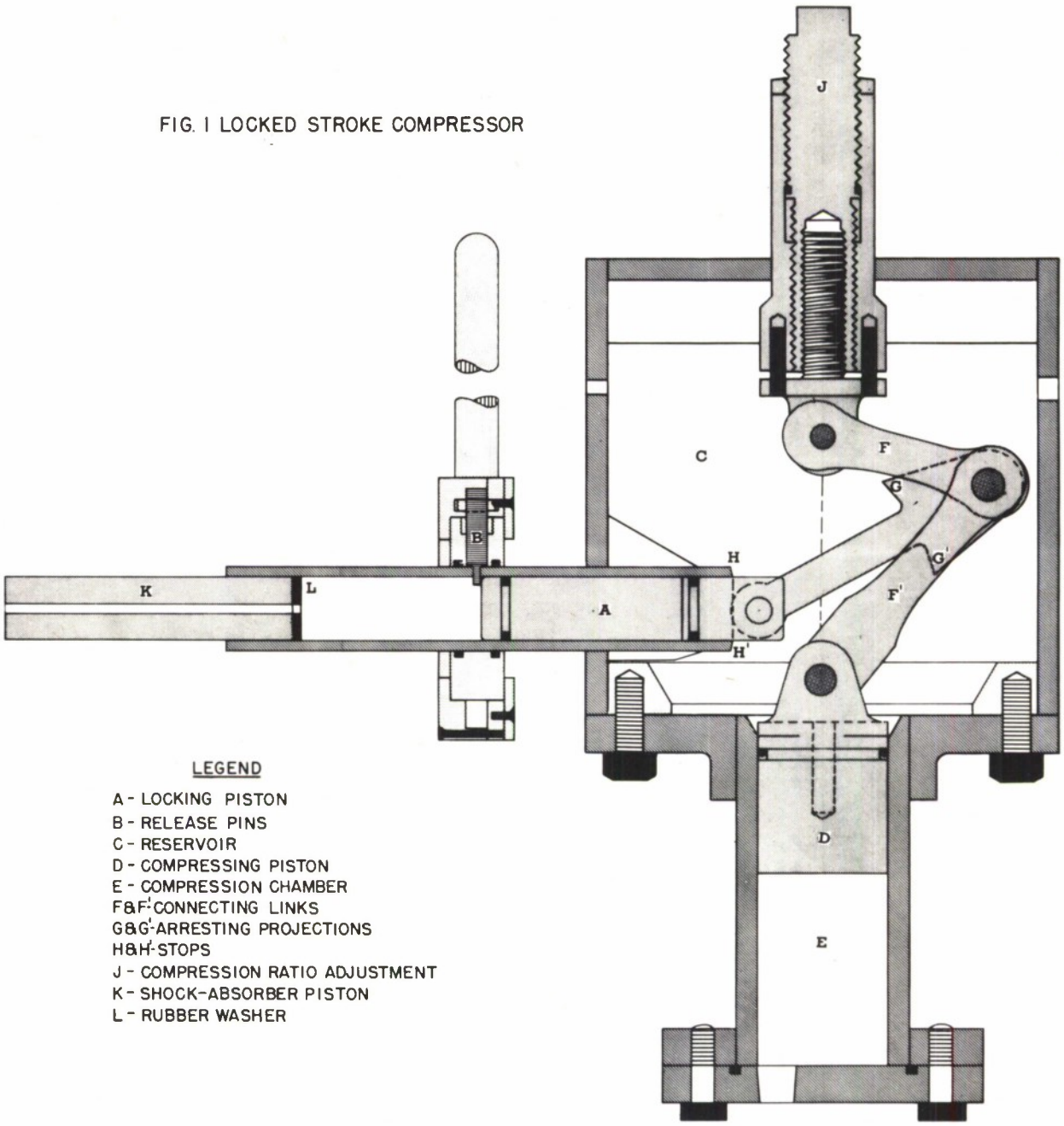
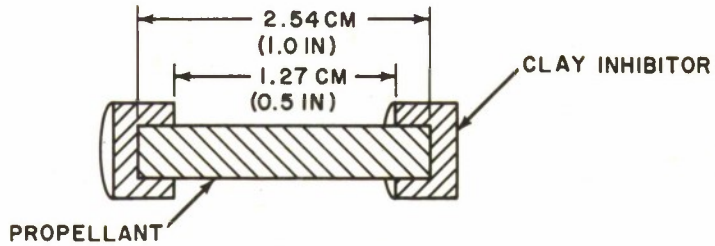
FIG. 1 LOCKED STROKE COMPRESSOR



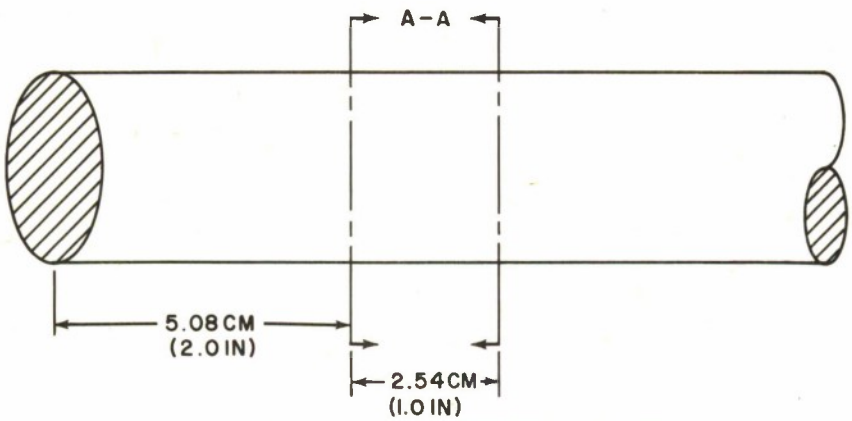
LEGEND

A - LOCKING PISTON
B - RELEASE PINS
C - RESERVOIR
D - COMPRESSING PISTON
E - COMPRESSION CHAMBER
F&F' CONNECTING LINKS
G&G' ARRESTING PROJECTIONS
H&H' STOPS
J - COMPRESSION RATIO ADJUSTMENT
K - SHOCK-ABSORBER PISTON
L - RUBBER WASHER



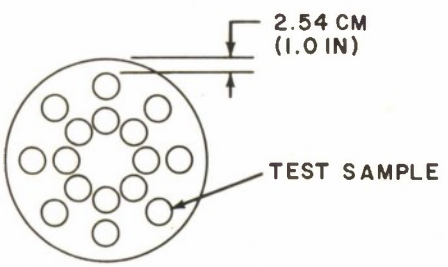
CUT AWAY VIEW OF PROPELLANT
SAMPLE USED IN TEST

2C



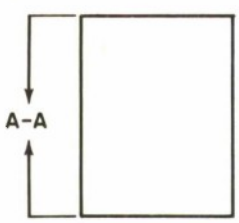
SAMPLE AS RECEIVED FROM MANUFACTURE

2B



END VIEW OF SECTION A-A
SHOWING SAMPLING POSITIONS

2A



SIDE VIEW OF SECTION
A-A

FIG. 2 DIAGRAM OF SAMPLING STEPS

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